Neurochaeta inversa McAlpine (Diptera: Neurochaetidae) and Seed Set in *Alocasia macrorrhiza* (L.) G. Don (Araceae) in southeast Queensland

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Forty one intact infructescences of *Alocasia macrorrhiza* (L.) G. Don were examined for presence or absence of *Neurochaeta inversa* McAlpine and for numbers of seed set. *N. inversa* was recorded in all the spathal chambers of 20 infructescences in two rainforest localities, in only two chambers of nine infructescences from two natural stands in cleared areas, but not at all in chambers of 12 infructescences from cultivated garden plants. Numbers of seed were not correlated with the numbers of *N. inversa* in the chambers, and seed was still set at sites where no *N. inversa* was recorded. Pollination, therefore, is probably independent of ovipositing females of *N. inversa*.

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INTRODUCTION

Alocasia macrorrhiza (L.) G. Don is a large aroid commonly known as 'cunjevoi' in Australia. Its inflorescence consists of a spathe and spadix (Fig. 1, **A**). The spathe is divided into a terminal expanded portion (the spathal blade) and a convoluted persistent base (the spathal tube) which forms the spathal chamber. The spadix consists of four sections (Fig. 1, **B**) which, from the tip downwards, are: the sterile terminal appendage; the staminate portion with synandria bearing the pollen; the median sterile (m.s.) florets of the constricted portion and the pistillate flowers or ovaries (with ovules) at the base. The stigmas are receptive prior to anthesis. After fertilization, the tip of the spathal tube tightly clasps the constricted portion of the spadix, forming the 'sealed' spathal chamber. The unfertilized ovaries in the sealed chamber persist on the maturing infructescence and remain about the same size as at anthesis, but fertilized ovaries (berries) enlarge to accommodate the developing fertilized ovules (seed). The berries, green at first, turn yellow and then red at maturity. The spathal tube also enlarges to accommodate the developing seeds. At maturity, the walls of the spathal tube turn from green to yellow, and split longitudinally into four or five segments which unfurl by rolling outwards revealing the ripe berries.

McAlpine (1978) described *Neurochaeta inversa,* noting that it is only known to occur in association with *A. macrorrhiza* in its original habitat in or at the edge of

TABLE 1

Number and percentage of fertilized ovaries (berries) and numbers of seed and N. inversa *per head, site, locality and habitat*

HABITAT, locality	Site, head designation	Fertilized ovaries (berries) per head		Seed per head				*N. inversa* per head			
		No.	%	No.	Site Av. No.	Locality Av. No.	Habitat Av. No.	No.	Site Av. No.	Locality Av. No.	Habitat Av. No.
RAINFOREST							137.1				29.6
Lamington						144.7				22.7	
Plateau	O'R				144.7				22.7		
	1	111	51.4	181				31			
	2	51	27.9	66				20			
	3	114	57.3	187				17			
Mt Glorious						135.7				30.8	
	F				183.0				44.0		
	2	120	96.0	185				46			
	3	81	95.3	180				42			
	R (L)				10.7				29.0		
	2	17	18.3*	18				26			
	3	8	5.8*	8				34			
	4	6	4.2*	6				27			
	R (R)				180.5				38.0		
	6	80	47.9	120				49			
	7	117	95.1	241				27			
	M				220.0				41.0		
	3	90	82.6*	166				35			
	4	151	70.6	205				45			
	5	191	91.4*	354				76			
	6	137	93.2	277				4			
	7	68	54.8	98				45			
	H				89.6				13.4		
	2	71	54.2	79				3			
	3	102	87.9	142				18			
	4	94	54.7	133				2			
	5	12	14.3	14				6			
	6	55	52.9*	80				38			
INTERMEDIATE ZONES							77.4				2.0
Upper Brookfield						102.3				3.0	
	Sm				102.3				3.0		
	1	77	61.1	118				0			

TABLE 1—*continued*

Number and percentage of fertilized ovaries (berries) and numbers of seed and N. inversa *per head, site, locality and habitat*

HABITAT, locality	Site, head designation	Fertilized ovaries (berries) per head		Seed per head				*N. inversa* per head			
		No.	%	No.	Site Av. No.	Locality Av. No.	Habitat Av. No.	No.	Site Av. No.	Locality Av. No.	Habitat Av. No.
	2	68	61.3	116				0			
	3	17	15.7	37				13			
	4	36	27.5	50				0			
	5	99	76.7	143				0			
	6	110	80.3	150				5			
Beechmont						27.7				0.0	
	K				27.7				0.0		
	1	5	3.5	6				0			
	2	26	10.1	35				0			
	3	29	17.0	42				0			
GARDEN							112.3				0.0
Chapel Hill						124.0				0.0	
	S				124.0				0.0		
	1	99	79.8	124				0			
Mt Coot-tha						112.3				0.0	
	AR				75.5				0.0		
	4	31	20.8	40				0			
	5	81	49.4	111				0			
	ER				222.5				0.0		
	6	91	62.3	160				0			
	7	156	98.1	285				0			
	MC				63.3				0.0		
	3	19	9.8	26				0			
	4	131	85.1	153				0			
	5	10	5.5	11				0			
St Lucia						109.3				0.0	
	NR				109.3				0.0		
	1	104	91.2	153				0			
	2	56	44.8	61				0			
	3	54	33.3	63				0			
	4	113	63.8	160				0			

*Ovaries with wet rot (see Table 5) not included, because of impossibility of distinguishing whether fertilized or not.

rainforest and not with cultivated examples. Adults live on both sides of the leaf blade, on the outer surface of the petiole, within the petiolar cleft and in the spathe of the inflorescence at anthesis. Eggs (which were not observed) are apparently laid on the female part of the inflorescence and larvae live between the developing fruitlets where they are in contact with a 'watery liquid' found within the spathe which forms a sealed chamber during the whole of the larval development. Pupariation, and often emergence of adults, takes place while the fruitlets are still unripe and the spathe sealed. The adults, therefore, cannot escape until the spathe splits at maturity. He stated that ovipositing females of *N. inversa* may act as pollinators of *A. macrorrhiza*, but observed that, as many insects visit the flowers, they are probably not the sole pollinating agents.

In studies carried out in southeast Queensland in 1980 and 1981, numbers and percentages of fertilized ovaries (berries), numbers of fertilized ovules (seed) and insects found in the sealed chambers of infructescences were recorded in order to determine whether any correlation exists between the numbers of seed set and numbers and types of insects recorded in the chambers.

Sites and Samples

Samples were from plants in three general habitats, viz., rainforest, intermediate zones of remnant natural stands in mainly cleared areas, and in gardens. The localities and brief descriptions of the sites are as follows:

1. *Rainforest* — Samples were from clumps in small private holdings, adjacent to large or relatively large reserved areas of rainforest, as below:
   - Lamington Plateau: Site O'R, on creek in mixed rainforest/sclerophyll area.
   - Mt Tamborine: Site BC, on creek in open area near rainforest and sclerophyll forest.
   - Mt Glorious: Sites F, R (L), R (R), H, M, in rainforest, some near dirt road, some near small clearings or thinned rainforest.
2. *Intermediate zones*
   - Upper Brookfield: Site Sm, isolated natural stand on dry creek in cleared area of secondary growth and weeds; general area under crop and artificial grassland; nearest rainforest remnant about 0.3 km distant.
   - Beechmont: Site K, isolated natural stand on dry creek surrounded by artificial grassland and weeds; nearest rainforest remnants about 0.5 km distant.
3. *Garden*
   - Chapel Hill: Site S, one cultivated plant in suburban garden; area with housing and gardens, and remnant sclerophyll and rainforest.
   - Mt Coot-tha: Sites AR, ER and MC, scattered planted clumps, some near creek, in suburban Mt Coot-tha Botanic Gardens; area originally sclerophyll forest, planted to simulated rainforest during the last three years.
   - St Lucia: Site NR, large planted clump near creek in small simulated rainforest surrounded by parklands in the University of Queensland.

Each site was sampled once except Mt Coot-tha (twice) and Mt Glorious (three times).

The samples consisted of 54 infructescences or heads which were examined for insects. Forty-four heads had intact and sealed spathal chambers; of these, 41 were examined for seed set and three especially for physiological maturity. Ten other heads were too young for seed or had damaged spathal tubes. The samples were at various stages of development from anthesis to near-maturity.

Counts for insects and other organisms were made by removing each spathal tube in four or five longitudinal strips and examining the inside of each strip immediately under the stereomicroscope for larvae, pupae, etc., any detected being removed to vials for later study. Any liquid in the spathal chamber was also examined. The outer surfaces of the ovaries were examined microscopically in situ and any organisms removed to vials. Each ovary was then removed with forceps while still under microscopic observation, this being especially necessary in order to detect colourless larvae around the ovary bases and on the white spadix core.

Seed and Insect Records

Numbers of fertilized ovaries (berries) per head

The number and percentage of fertilized ovaries (berries) per head for 41 heads with intact, sealed chambers, are given in Table 1. There was considerable variation in the number of berries per head (six to 191), and in the percentage of berries per head, which ranged from 3.5% to 98.1%. The three heads from Beechmont (Site K) all had a low number of fertilized ovaries, viz., 3.5%, 10.1% and 17.0%. The numbers were also low for the three heads from Site R(L), Mt Glorious, with 18.3%, 5.8% and 4.2%.

Numbers of seed per head

The numbers of seed per head are given in Table 1, ranging from six seeds in six berries (an average of 1.0 seeds per berry) to 354 seeds in 191 berries (an average of 1.9 seeds per berry).

The lowest averages of seed per head per site were for Site R(L), Mt Glorious, and Site K, Beechmont, with 10.7 and 27.7 seeds per head per site respectively, while the highest were at Site M, Mt Glorious, and Site ER, Mt Coot-tha, with 222.0 and 222.5 seeds per head per site respectively. Statistical analysis showed that differences between some sites are significant at either the 5% or 1% level (Table 2).

TABLE 2

Statistical analysis of average numbers of seeds per head per site

Habitat, locality	Site* Design-ation	Site* Num-ber#	Seeds per head per site Av. No.	Sites (numbered as in third column) significantly less than designated site 5% level	1% level
Rainforest					
Lamington	O R		144.7	Sites *3, 8*	
Plateau		*1*			
Mt Glorious	F	*2*	183.0	Sites *8, 11*	Site *3*
	R(L)	*3*	10.7		
	R(R)	*4*	180.5	Site *8*	Site *3*
	M	*5*	220.0	Sites *9, 12*	Sites *3, 6, 7, 8, 11*
	H	*6*	89.6		

TABLE 2—*continued*

Habitat, locality	Site* Design-ation	Site* Num-ber#	Seeds per head per site Av. No.	Sites (numbered as in third column) significantly less than designated-site 5% level	Sites (numbered as in third column) significantly less than designated-site 1% level
Intermediate Zones					
U. Brookfield	Sm	*7*	102.3	Site *3*	
Beechmont	K	*8*	27.7		
Garden					
Mt Coot-tha	AR	*9*	75.5		
	ER	*10*	222.5	Sites *6, 7, 9, 12*	Sites *3, 8, 11*
	MC	*11*	63.3		
St Lucia	NR	*12*	109.3	Site *3*	

* Garden site 1 at Chapel Hill omitted because only one sample.
\# Sites numbered consecutively for statistical analysis.

Less variation was shown in the average numbers of seed per head per locality, which ranged from 27.7 for Beechmont to 144.7 for Lamington and even less variation in the average numbers of seed per head per habitat, being 77.4 for the intermediate zones, 112.3 for garden areas and 137.1 for rainforest (Table 1).

Insects

The only insects found within undamaged, still-sealed heads were 1) *N. inversa,* 2) Nitidulidae and 3) a few miscellaneous organisms, as below:

1. *N. inversa*

The eggs were not located. The numbers of larvae, puparia (with pupae or empty) and adults recorded in the spathal chambers of the intact heads with seed are shown in Table 3, and the totals are also inserted in Table 1. The numbers of adults are given in brackets in Table 3, and are not included in the totals, as those individuals are presumably already included in the numbers of empty puparia.

TABLE 3

Occurrence of N. inversa *and Nitidulidae in 41 heads of* A. macrorrhiza

Habitat, locality, site	Head design-ation	*N. inversa* Larvae	*N. inversa* Puparia with pupa	*N. inversa* Puparia empty	*N. inversa* Adults	Total	Nitidulidae Larvae	Nitidulidae Adults
		No.	No.	No.	No.	No.	No.	No.
Rainforest								
Lamington Plateau								
O'R	1	31	0	0	0	31	3	0
	2	2	18	0	0	20	0	0
	3	0	6	11	0*	17	1	0
Mt Glorious								
F	2	0	0	46	0*	46	n.s.+	n.s.+
	3	0	0	42	0*	42	n.s.+	n.s.+
R(L)	2	0	16	10	0*	26	2	0
	3	4	25	5	0*	34	2	0
	4	8	19	0	0	27	1	0

TABLE 3—*continued*

Occurrence of N. inversa *and Nitidulidae in 41 heads of* A. macrorrhiza

Habitat, locality, site	Head design-ation	*N. inversa* Larvae	Puparia with pupa	Puparia empty	Adults	Total	Nitidulidae Larvae	Nitidulidae Adults
		No.	No.	No.	No.	No.	No.	No.
R (R)	6	2	29	18	0*	49	2	0
	7	21	5	1	0*	27	2	2
M	3	35	0	0	0	35	3	0
	4	32	44	1	0*	45	0	0
	5	64	11	1	0*	76	1	0
	6	0	1	3	0*	4	2	0
	7	0	44	1	(1)#	45	0	0
H	2	1	2	0	0	3	1	0
	3	16	2	0	0	18	9	0
	4	0	0	2	0	2	5	0
	5	0	4	2	(2)#	6	0	0
	6	0	6	32	(17)#	38	1	0
Intermediate Zones								
Upper Brookfield								
Sm	1	0	0	0	0	0	11	0
	2	0	0	0	0	0	0	0
	3	0	3	10	0*	13	2	0
	4	0	0	0	0	0	0	1
	6	0	0	5	0*	5	0	0
Beechmont								
B	1	0	0	0	0	0	7	0
	2	0	0	0	0	0	2	0
	3	0	0	0	0	0	0	0
Garden								
Chapel Hill								
S	1	0	0	0	0	0	n.s.+	n.s.+
Mt Coot-tha								
AR	4	0	0	0	0	0	0	0
	5	0	0	0	0	0	2	0
ER	6	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0
MC	3	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
St Lucia								
NR	1	0	0	0	0	0	2	0
	2	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0

* Some adults apparently escaped without detection during the opening of the chamber

\+ n.s. = not sought

\# Numbers of adults given in brackets not included in the total, because the individuals already counted in the numbers of empty puparia.

All heads sampled from rainforest sites had one or more stages of *N. inversa*, while in heads from intermediate zones, only two out of nine heads sampled had any stage of the fly, and then only in low numbers. No *N. inversa* were recorded in heads from garden areas.

Because of the number of zero values in the intermediate and garden sites, the

data were transformed ($x = \sqrt{x + \frac{1}{2}}$) and the transformed means show that both the intermediate and garden sites differ significantly at the 5% or 1% levels from the rainforest sites in numbers of *N. inversa* present (Table 4).

The numbers of *N. inversa* individuals per head, together with average numbers per site, locality and habitat, are shown in Table 1. *N. inversa* was recorded in all heads at all the rainforest sites, as reported previously, and seed set per head for these ranged from 4.2% to 96.0%. In the intermediate zones, only two heads at the Upper Brookfield site had a small number of *N. inversa* with 15.7% and 80.3% seed set respectively, while the four heads without *N. inversa* at this site had 27.5% to 76.6% seed set. None of the three heads from Beechmont had *N. inversa,* but seed set was 3.5%, 10.1% and 17.0% respectively. In the garden sites, where *N. inversa* was absent, seed set ranged from 5.5% to 98.1%. This latter figure, in fact, was the highest percentage of seed recorded in this study.

TABLE 4

Statistical analysis of average numbers of N. inversa *per head per site*

HABITAT, locality	Site* Design-ation	Num-ber#	*N. inversa* per head per site Av. No.+	Sites (numbered as in third column significantly less than designated site 5% level	1% level
RAINFOREST					
Lamington Plateau	O'R	*1*	22.3		Sites *7, 8, 9, 10, 11, 12*
Mt Glorious	F	*2*	44.0		Sites *6, 7, 8, 9, 10, 11, 12*
	R(L)	*3*	28.9	Site *6*	Sites *7, 8, 9, 10, 11, 12*
	R(R)	*4*	37.2	Site *6*	Sites *7, 8, 9, 10, 11, 12*
	M	*5*	36.3		Sites, *6, 7, 8, 9, 10, 11, 12*
	H	*6*	10.4	Sites *7, 8, 9, 10, 11*	Site *12*
INTERMEDIATE ZONES					
U. Brookfield	Sm	*7*	1.7		
Beechmont	K	*8*	0.0		
GARDEN					
Mt Coot-tha	AR	*9*	0.0		
	ER	*10*	0.0		
	MC	*11*	0.0		
St Lucia	NR	*12*	0.0		

* Garden Site 1 at Chapel Hill omitted because only one sample.
\# Sites numbered consecutively for statistical analysis.
\+ Transformed means.

A co-variance analysis was carried out on seed number per site using the numbers of *N. inversa* as a co-variate, and the regression is not significant.

2. *Nitidulidae*

Larvae of Nitidulidae (Coleoptera) and more rarely, adults, were found in low numbers in some heads at most sites (Table 3), particularly at rainforest and Beechmont sites. The larvae mainly occurred in the m.s. florets undergoing deliquescence, on the inner face of the spathal tube and only rarely on the berries.

3. *Other insects etc.*

Other insects and organisms found in undamaged, sealed spathal chambers are recorded in Table 5. They were mainly larvae of unknown Diptera, Ceratopogonidae (biting midges), oligochaete worms and crustaceans (Syncarida: ?Bathynellacea).

TABLE 5

Occurrence of other insects etc. and damaged berries in 41 heads of A. macrorrhiza

Habitat, locality, site	Head design-ation	Insects etc.	Prick lesion*	Damaged berries with Hole with some rot No.	%	Wet rot# into spadix core No.	%
Rainforest							
Mt Glorious							
R (L)	2		-			18	19.4
	4		-			28	19.7
R (R)	6		++	1	0.6		
	7	Few Oligochaeta (worms)	++	6	4.9″		
M	3		++			2	1.8
	4		-			37	17.3
	5		-			2	1.0
	6		++	1	0.7		
	7		-	2	1.6″		
H	5		+				
	6	6 Ceratopogonidae larvae 3 Unknown Diptera larvae 2 Diptera puparia 1 dead flying ant	-	4	3.9	29	22.7
Garden							
Mt Coot-tha							
MC	3	3 dead adult Thripidae	-				
St Lucia							
NR	1	16 Ceratopogonidae larvae 1 Aphididae (1 apterous, 1 immature) 1 ? Hymenoptera (prepupa)	-	4	3.5		
	2	3 Oligochaeta (worms)	-				
	3	4 Oligochaeta (worms)	-	2	1.2		
	4	10 (approx). ? Bathynellacea (Syncarida) Crustacea *Fusarium* sp. (fungus) (sp.1) (fine web and spores over the berries)	-	4	2.3		

* + = 'prick' lesions present; ++ = abundant; - = absent.

\# Impossible to determine whether rotted structures were berries or unfertilized ovaries.

″ Rot extending into spadix core.

Insects in young or damaged Heads

Insects and other organisms in ten other heads which were either too young to have seed, or where the spathal tube was damaged or gaping, are reported in Table 6. *N. inversa* larvae, puparia and adults were recorded inside the spathal chambers of most of these rainforest heads. Nitidulid larvae and a few adults were found either outside or inside the spathal chambers, in the latter case mainly near or in the decaying m.s. florets at the tip of the chamber. Eggs of Chloropidae (Diptera) were found mainly inside the chambers of heads picked while the spathal limb was still extended and unwilted, while the larvae were found in decaying tissue outside and inside the spathal chambers. Two species (*Cadrema* sp. and *Hippelates* sp.) were reared from larvae in the laboratory, and one specimen of each species was parasitized by a cynipid wasp (Hymenoptera: Cynipidae: Eucoilinae). The large (0.6 × 0.24 mm) opaque white eggs on Mt Glorious heads have not been identified. Only one

ceratopogonoid larva was recorded on a Mt Glorious head. Brachypterous female Phoridae (Diptera) were found in the decaying tissue of two damaged heads from Mt Coot-tha.

TABLE 6

Insects recorded in ten young or damaged heads of A. macrorrhiza, *not reported in previous tables*

HABITAT, locality site, head designation	Head maturity and position of insects	Insects, etc. *N. inversa* No.+	Nitidulidae No.+	Chloropidae No.+	Miscellaneous No.+
RAINFOREST					
Mt Glorious					
R(L)					
Head 5	Very young, spathal limb still present; no difference in ovary sizes				
	In plastic bag after transport		1L		1 Diptera L
			4A		1 Staphylididae L
	In debris at tip on outside of spathal tube		11L	20L	
	Inside spathal chamber	33L	1L	98#E	1 Large white egg
					Few flatworms?
Head 8	Prior to anthesis, held in lab. 18 days; no enlargement of ovaries but constriction closed				
	Inside chamber near tip	1L	20L	28#E	1 Ceratopogonidae L
		3P		15L	
				4P	
				2A	
R(R)					
Head 9	Very young, spathal limb still present; held in lab. 4 days; no perceptible difference in ovary sizes				
	In decaying florets outside spathal chamber		1L	3L	
	Inside chamber	2L		x+E	1 large white egg
				7L	
Head 10	Very young, spathal limb still present; held in lab. 5 days; hardly perceptible difference in ovary sizes				
	Inside chamber	40L		97#E	8 large white eggs
				24L	
M					
Head 1	Head net bagged before anthesis; 1 ovary slightly enlarged				
	Inside spathal flap			4E	
	Inside spathal chamber	47L			(Some 'prick' lesions present)
		5P			
Head 8	Head ripe with partially opened spathal tube				
	Inside chamber	8P			
H					
Head 7	Head with slight rot of spathal tube tip				

TABLE 6—*continued*

Insects recorded in ten young or damaged heads of A. macrorrhiza, *not reported in previous tables*

HABITAT, locality site, head designation	Head maturity and position of insects	Insects, etc. *N. inversa* No.+	Nitid-ulidae No.+	Chlor-opidae No.+	Miscell-aneous No.+
	Inside chamber	2P 2A		4L	
Head 8	Head with slight rot of spathal tube tip				
	Inside chamber	15P		2P	
GARDEN					
Mt Coot-tha					
MC					
Head 1	Staminate portion deliberately severed before anthesis; later rest of spadix rotting				
	In rotting florets				3 Phoridae A
Head 2	Small hole with some rot into spathal chamber				
	In rotting spadix		19L 1A		15 Phoridae A

*E = egg; L = larva; P = puparium; A = adult.

Probably more eggs present but uncounted.

+ Eggs uncounted.

BIOLOGY OF *NEUROCHAETA INVERSA*

The development of *N. inversa* from larva to adult within the sealed spathal tube of *A. macrorrhiza* seems fairly precisely adjusted to the maturation of the infructescence. Details of the maturation of the head will be given separately by D.E.S., but the part of the process relevant to the spathal chamber and the chamber liquid may be summarized as follows: The portion of the spadix (consisting of the terminal sterile appendage, the staminate section and the upper part of the m.s. florets) distal to the constriction withers and falls off. The spathal blade also withers and falls off, usually in its entirety. The tip of the spathal tube constricts to form the sealed spathal chamber (Fig. 1, **C**) which encloses the lower part of the m.s. florets and the pistillate flowers or ovaries. The enclosed m.s. florets then undergo deliquescence, leaving the spadix core bare and contributing to a broth of liquid and flower-part remains. This broth bathes the surface and sides of the ovaries in the sealed chamber and the broth debris often accumulates near or at the base of the chamber. In some young heads, the enclosed liquid, which may not all have been derived from the dissolution of the m.s. florets, measured up to 8 cc.

Larvae of *N. inversa* were usually found on the inner face of the spathal tube, in the broth from the spathal chamber (Fig. 1, **D**) or on the outer faces of the exposed berries and unfertilized ovaries. These latter larvae, however, moved rapidly between the ovaries when the spathal tube was removed, and were usually only retrieved by the removal of the berries and unfertilized ovaries. The development of the larvae coincides with the deliquescence of the m.s. florets, as described above, so that when the broth resulting from the dissolution is abundant, the larvae are present. Not all the larvae in any one head pupariate at exactly the same time, so that in some cases both larvae and puparia occur together in the same chamber (Table 3), often with the remains of the m.s. florets still discernible. However, by the time all the larvae have pupariated the remains of the m.s. florets have virtually disappeared, together with most of the liquid. There is some latitude in this sequence, however, regarding

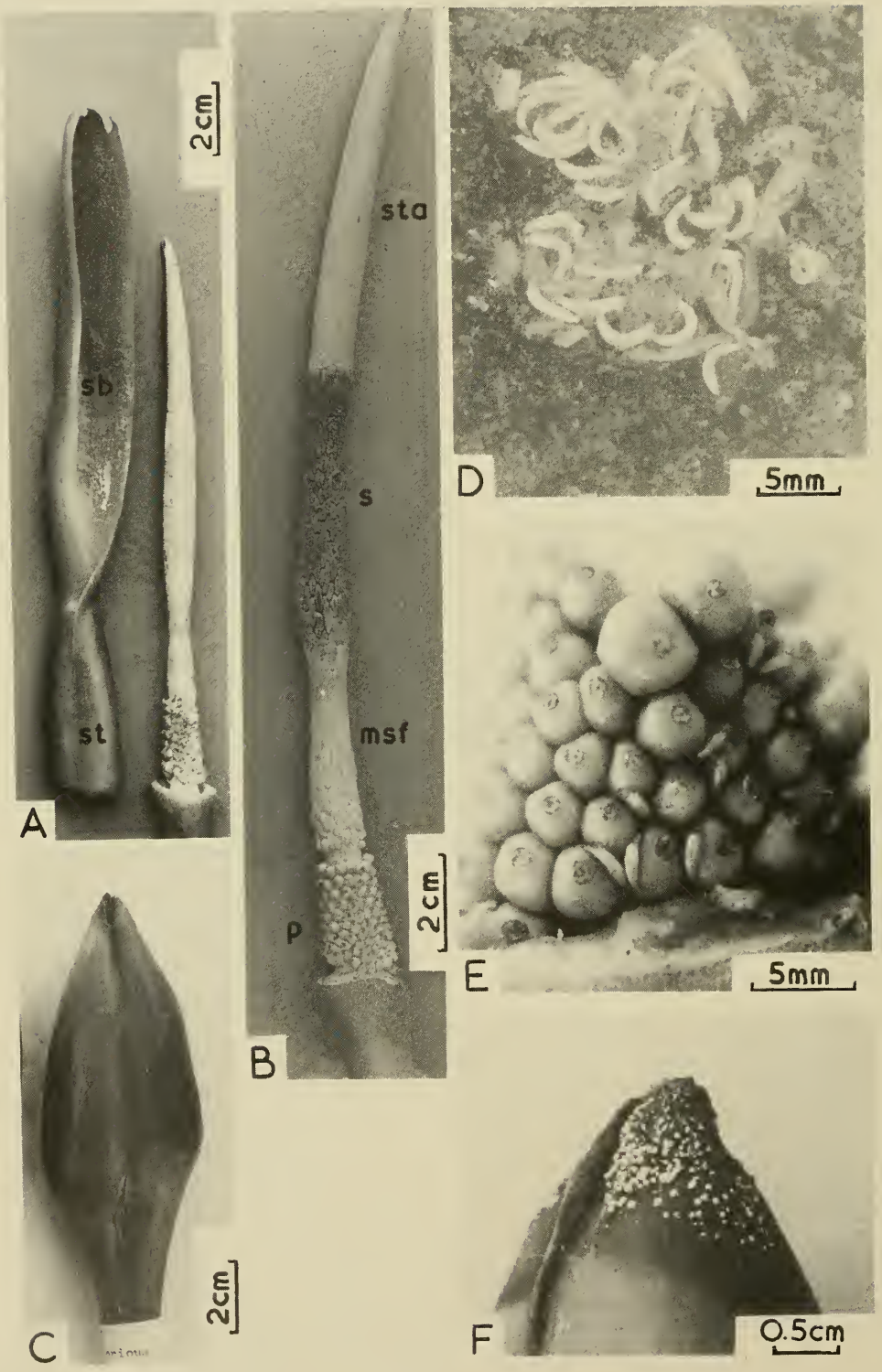
2cm
sb
st
A
sta
s
msf
p
2cm
B
D
5mm
E
5mm
2cm
C
F
0.5cm

TABLE 7

Infructescence maturity, amount of liquid in spathal chamber and stages of N. inversa *in heads from Mt Tamborine*

Site, head designation	Maturity of head (All heads with spathal tubes still green)	Amount of liquid in spathal chamber	Stages of *N. inversa*			
			Larvae	Puparia	Puparia with empty pupae	Adults
			No.	No.	No.	No.
BC						
Head 2	Berries enlarged, green	trace	0	2	11	5*
Head 4	Berries larger, green	about 0.5 cc	0	16	30	29*
Head 3	Berries largest, turning yellow at base (therefore ripest)	about 1 cc	1	4	7	2*

* Some adults apparently escaped without detection during the opening of the chamber.

maturity of the head, amount of liquid remaining in the chamber, and stage of development of *N. inversa*. This is shown, for example, in three heads from Mt Tamborine (Table 7), not included in the other tables. Head 3 from Mt Tamborine was the only one, out of over 50 heads studied, where all three stages (larva, puparia and adults) occurred at the same time. Although its berries were more mature than those on Heads 2 and 4, its chamber contained more liquid than the other two chambers, and this may have contributed to the presence of the larva.

The puparia were oriented with the posterior end downwards between the berries, and with the flattened or slightly depressed facet at the anterior end usually parallel to the surface of the spathal tube (Fig. 1, E). In a few cases puparia were found between the base of the ovaries, probably dislodged during transport of the head from the field.

McAlpine (1978) reported that the adults which emerge from the puparia cannot escape from the spathal chamber until the fruits are ripe and the spathal tube splits. In this study, adults were present in Heads 5 and 6, Site H, and in Head 7, Site M, at Mt Glorious (Table 3) and also in all three heads from Mt Tamborine (Table 7), and in all cases the spathal tubes were still green, without any yellowing which indicates approaching maturity and which precedes splitting of the tube. The adults were quick to escape from any artificial opening made in the tube, and perhaps escape naturally as soon as the slighest relaxation occurs in the tube, even possibly prior to splitting.

Information is still required as to whether the adults feed after emergence while still within the chamber, and whether they remain quiescent between the berry shoulders, or make their way to the tip of the chamber and congregate around the spadix core bared by the dissolution of the m.s. florets, waiting for the first opportunity to escape.

N. inversa larvae were never noted causing damage to the ovaries or to the spadix core. No parasites were recorded in any of the specimens.

Fig. 1. **A,** Spathe (left, detached) with spathal blade (sb) and spathal tube (st) and spadix (right) of *Alocasia macrorrhiza*. **B,** Later stage of the spadix showing sterile terminal appendage (sta); staminate flowers (s); median sterile flowers (msf) and pistillate flowers (p). **C,** 'Sealed' spathal tube enclosing berries. **D,** Diptera larvae and 'broth' from spathal chamber. **E,** Puparia of *Neurochaeta inversa* and berries of *A. macrorrhiza*. **F,** Tip of spathal tube with rot and sporulating fungus (*Fusarium* sp.).

Damage to infructescence Parts

Damage to berries in sealed, intact heads was of three types, viz., 1) 'prick' lesions, 2) hole in the berry wall, and 3) wet rot of the berry. Rot of the spathal tube tip (point 4. below), resulting in gaping, occurred in three other heads.

1. *'Prick' lesions*

In some heads (Table 5) at sites at Mt Glorious, minute red 'prick' lesions were noted on some berry walls. In a few cases a narrow border of slightly more translucent tissue surrounded the 'prick', but even then the whole diameter of the lesion was still only about 0.5 mm. In no case did any rot of the berry wall or the underlying seeds appear to be associated with these 'prick' lesions. The lesions may have been caused by stylet penetration of the pistillate flowers before anthesis by an unknown insect.

2. *Hole in berry*

A hole in the berry wall, sometimes with damage to the enclosed seed, occurred in 14 berries from Mt Glorious and 10 from St Lucia (Table 5). The hole was usually near the base of the berry, and such damage tended to cause a premature change in the colour of the berry wall from green to yellow and even to red. In some cases the damage extended into the spadix core, causing a reddish wet rot at the site of berry attachment. Although larvae of Ceratopogonidae were occasionally found feeding within the holes in the berries, this may merely indicate opportunism and not necessarily a causal relationship.

3. *Wet rot of ovaries*

Wet rot of 116 ovaries (or berries, as it was impossible to determine whether fertilization had taken place or not) was noted in six heads from Mt Glorious (Table 5), one case involving 22.7% of the ovaries on the head. If adjacent ovaries were affected, counts were made on stigmas rather than on the ovaries themselves, as it was difficult to distinguish the individual rotting bodies. In each case the rot extended into the spadix core, again with a wet reddish discolouration of the tissue. It is not known whether the wet rot is an extension of the 'hole' condition described above, or whether it is quite distinct. The latter may be the case, as no wet rot was recorded in the St Lucia heads, whereas holes did occur in 10 berries on three heads from this site.

4. *Rot of tip of spathal tube*

Three heads, including Heads 7 and 8 from Site H, Mt Glorious (Table 6), and an unlisted pathology specimen head from Site R (R) at Mt Glorious, had a rot of the spathal tube beginning at the tip, and proceeding downwards, with white sporulating fungal clumps on the rotted tissue (Fig. 1, **F**). The fungus, which was obtained in axenic culture, was *Fusarium* sp. 2 (see Addendum), different from *Fusarium* sp. 1 recorded as a fine sporulating web on Head 4, St. Lucia (Table 5). Further investigation is required to determine whether *Fusarium* sp. is a primary pathogen, or, as would seem more likely, a secondary invader following damage by an unknown agent.

General Discussion

McAlpine (1978) reported that larvae of *Cadrema* sp. (Diptera: Chloropidae) were found in the moist decaying upper part of the spadix of *A. macrorrhiza,* and has confirmed it (pers. comm.) to be the same species as that found in the present study. We also found larvae of *Hippelates* sp. (Chloropidae) and Nitidulidae occupying that niche provided by the dissolution of the m.s. florets at the tip of the spathal chamber and in the decaying spadix parts outside the spathal chamber. It is not known if they also occur on the decaying distal portion of the spadix which usually withers and falls off the infructescence. If so, the life cycle of these two groups may be completed in the decaying tissue on the ground.

Some of the miscellaneous organisms found in the sealed chambers, such as the Ceratopogonidae (biting midges), the oligochaete worms and the ?Bathynellacea (Crustacea: Syncarida) may be chance visitors caught within the chambers before sealing. Oligochaete worms and midges were only recorded in sealed intact heads from St Lucia and Mt Glorious. The worms, however, are difficult to see, and low numbers may have been missed in heads from other sites. The presence of the worms seemed to be associated with thin rings of debris on the inner surface of the spathal tube, although it was not possible to confirm the connection.

One of the interesting aspects revealed by this study was the considerable variation in seed set on different heads at the one site (Table 1). Whether this was the result of differences in numbers of the pollinating agent(s), or in the amount of available pollen, or in microclimatic factors at the time of stigma receptivity of each head, is not known.

McAlpine (1978) stated that ovipositing *N. inversa* females may well be pollinators of *A. macrorrhiza,* but observed that, as many insects visit the flowers, they are probably not the sole pollinating agents. As shown in Table 1, the numbers of seed set were not related to the numbers of *N. inversa* recorded in the chambers at the sites where the fly was found. McAlpine (1978) further observed that *N. inversa* had not been found on cultivated examples of 'cunjevoi' and this was confirmed in the present study, as no *N. inversa* were recorded at these sites, although seed was still set as shown in Table 1. We conclude, therefore, that pollination of *A. macrorrhiza* is probably independent of ovipositing females of *N. inversa* in the inflorescence.

Carson and Okada (1980) previously noted that there appeared to be no difference in seed set of flowers of *Colocasia esculenta* (Araceae) from which adult *Drosophiella pistilicola* were excluded by bagging, and unbagged controls. They concluded, therefore, that the presence of this fly was not necessary for full pollination of the flowers. Their work, like that of the present authors, was concerned specifically with an insect associated with the sealed spathal chambers, and not with the elucidation of the roles which may be played by many other insects known to visit the exposed flower parts.

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ADDENDUM

Identifications of *Fusarium* spp. 1 and 2, mentioned in the section 'Damage to Infructescence Parts', now received from the Commonwealth Mycological Institute, United Kingdom, are *Fusarium solani* (Mart.) Sacc. and *F. oxysporum* Schlecht., respectively.